# METHOD FOR CONTROLLING SKIN TEMPERATURE DURING THERMAL TREATMENT

## FIELD OF THE INVENTION

This invention relates to medical devices, and more specifically for such devices for use in dermatology.

## BACKGROUND OF THE INVENTION

There are many medical and cosmetic treatments that utilize electro-magnetic radiation to destroy a local defect in skin. Among these are laser-assisted hair removal, vascular lesion treatment and skin rejuvenation. In these treatments, the defect is irradiated, and heat formed in the skin in and near the defect, destroys the defect. The main problem limiting broad use of these treatments is the risk of thermal damage to skin surrounding the defect. One way to reduce this risk is to monitor skin temperature during the irradiation, and to stop the irradiation before the skin becomes overheated. However, surface skin temperature measurements give information relating only to the superficial skin layer, composed of dead cells (stratum corneum), while the temperature of the underlying living tissue can differ significantly.

One method for assessing tissue temperature relies on measurement of the electrical impedance of the tissue, which is temperature dependent. Tissue impedance decreases 1% to 3%° for every centigrade degree increase in temperature (Francis A. Duck, Physical properties of tissue, a Comprehensive Reference Book, Academic Press, 1990, p. 173). U.S Patent 5,643,257, discloses a

method for invasive thermal treatment of varicose veins, in which irradiation intensity is reduced when the tissue impedance drops below a predetermined value.

## SUMMARY OF THE INVENTION

The present invention provides a device and method for irradiating skin. In accordance with the invention, a skin defect is irradiated with electro-magnetic radiation. During the irradiation, measurements of an electrical parameter of the skin surrounding the defect are continuously obtained. The electrical parameter is preferably skin impedance, or a parameter known to be correlated with impedance such as conductivity, current and voltage. As the impedance decreases, the intensity of the irradiation is decreased in order to prevent the temperature of the skin surrounding the defect to rise to a level that is detrimental to the skin.

The invention thus provides a system for treating skin, comprising:

(a) a source of radiation configured to irradiate a region of the skin;

(b) at least a first pair of a first electrode and a second electrode, the first and second electrodes being configured to apply a voltage to the skin;

(c) an electrical meter configured to measure an electrical response of the skin to a voltage applied across the electrodes;

(d) a processor configured to adjust a value of a parameter of the radiation based upon a measured electrical response to a voltage applied across the first and second electrodes.

The invention further provides a method for treating skin, comprising:

(a) a source of radiation configured to irradiate a region of the skin;

(b) at least a first pair of a first electrode and a second electrode, the first and second electrodes being configured to apply a voltage to the skin;

(c) an electrical meter configured to measure an electrical response of the skin to a voltage applied across the electrodes;

(d) a processor configured to adjust a value of a parameter of the radiation based upon a measured electrical response to a voltage applied across the first and second electrodes.

## BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

**Fig. 1** shows a system for treating skin in accordance with one embodiment of the invention.

**Fig. 2** shows a system for treating skin in accordance with another embodiment of the invention.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to Fig. 1, a system is shown for treating skin in accordance with one method of the invention. A defect **100** in skin **105** is irradiated with electro-magnetic radiation **110** produced by a source **115.** The irradiation **110** has an intensity determined by a controller **120.** The controller **120** contains a voltage source **130** that applies an alternating voltage across a first electrode **125a** and second electrode **125b**. The second electrode **125b** may be a grounded electrode that is not connected to the processor **135** (not shown). An ammeter **135,** also located in the controller **120,** continuously measures a current flowing between the electrodes **125a** and **b**. An analog output **140** of the ammeter **135** is sampled by an analog to digital converter **145,** and the sample values are input to a processor **150.**

The processor **150** is configured to determine an electrical response of the skin **105** between the electrodes **125a** and **b** based upon a current measurement made by the ammeter **135.** The electrical response may, for example, be skin impedance or conductivity. The processor is further configured to determine a value of one or more parameters to determine the irradiation **110** based upon the electrical response of the skin **105.** The parameter may be, for example, intensity, pulse duration or pulse frequency. The processor **150** then adjusts the parameter of the radiation **110** to the determined value. For example, the processor may store in a memory **155** a table that assigns one or more parameter values to each of one or

more non-overlapping impedance ranges. In this example, the processor **150** searches in the table to determine to which impedance range the present impedance measurement belongs. The value of the parameter is then adjusted to the determined value. Typically, the values of the intensities, duration and frequency assigned by the table decrease as the impedance decreases which occurs as the skin temperature rises. In this way, overheating of the skin **105**, including its deeper layers, is avoided. As another example, the processor **150** may compare the present impedance measurement to a predetermined threshold value stored in the memory **155**. If the impedance measurement is above the predetermined threshold, the intensity, duration or frequency of the irradiation **110** is adjusted to a predetermined value. If the impedance is below the threshold, the irradiation **110** is turned off.

Referring now to Fig. 2, a system is shown for treating skin in accordance with another method of the invention. The system shown in Fig. 2 has components in common with the embodiment of Fig. 1, and similar components have the same numerical label in both figures. In this embodiment, a voltage applied across the electrodes **125a** and **b** by the controller **120** is used to measure the skin impedance as in the previous embodiment. In this embodiment, the voltage applied across the electrodes **125a** and **b** is also used to heat the defect **100**.

The processor **150** is configured to determine an electrical response of the skin **105** between the electrodes **125a** and **b** based upon a current measurement made by the ammeter **135**. The electrical response may be, for example, skin impedance or conductivity. The processor is further configured to determine a voltage based upon the electrical response of the skin **105**. The processor **150** then applies the determined voltage across the electrodes **125a** and **b**. For example, the processor may store in a memory **155** a table that assigns a voltage to each of one or more non-overlapping impedance ranges. In this example, the processor **150** searches in the table to determine to which impedance range the present impedance measurement belongs. The voltage assigned to this range is then applied across the electrodes **125a** and **b**. Typically, the voltages assigned by the table decrease as the impedance decreases. In this way, overheating of the skin **105**, including its deeper

layers, is avoided. As another example, the processor **150** may compare the present impedance measurement to a predetermined threshold value stored in the memory **155.** If the impedance measurement is above the predetermined threshold, a predetermined voltage is applied across the electrodes **125a** and **b**. If the impedance is below the threshold, no voltage is applied across the electrodes **125a** and b.